JP 2001-004605 A

TECHNICAL FIELD

[A technical field to which invention belongs] This invention relates to an internal combustion engine's fuel-injection control unit using a fuel vapor pressure sensor suitable for detecting vapor pressure of liquid fuel, such as a gasoline, based on various kinds of acoustic waves, such as an audible-sound wave and an ultrasonic wave, and this fuel vapor pressure sensor.

PRIOR ART

[Description of the Prior Art] Conventionally, generally the measuring method of the description of a gasoline has some which were defined in JIS. Even if it does not pass over this measuring method on mere criteria to the last but it uses the measurement result by the measuring method concerned for the gasoline of the internal combustion engine for mount as it is, it cannot control the injection quantity of an internal combustion engine's gasoline with a sufficient precision, for example.
[0003] a fuel as shown by JP,8-233787,A to this -- description -- it is possible to use the travelling period or acoustic velocity of an ultrasonic wave, to ask for the density of a gasoline, and to distinguish whether they are heavy [of the gasoline concerned], the quality of inside, and light ******** with distinction equipment, in order to judge the ease of carrying out of evaporation of the gasoline relevant to an internal combustion engine's injection quantity.

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] however, the above-mentioned fuel -- description -- with distinction equipment, since the travelling period or acoustic velocity

of an ultrasonic wave is changed with temperature, there is nonconformity that fluctuation of this temperature must be amended using the detection result of a temperature sensor.

[0005] On the other hand, this invention person etc. took lessons from the description of the gasoline used for an internal combustion engine, and inquired many things. Consequently, it turned out that it can ask by the acoustic velocity of an ultrasonic wave, without depending for the vapor pressure of a gasoline on temperature. It explains below about this point at details.

[0006] This equilibrium is expressed by the several 1 following formula, when vapor pressure of the gasoline within the air in right above [of the oil level of the gasoline as liquid fuel] is set to P and the equilibrium in the oil level of a gasoline is considered by setting the pressure in the gasoline as liquid fuel to Po.

[0007]

[Equation 1] P=Po-exp (-U/RT)

In this several 1 equation, R expresses the gas constant in a gaseous equation of state, and T expresses absolute temperature. Moreover, U expresses free energy and is given by the several 2 following formula.

[0008]

[Equation 2] U=-RT-ln (P/Po)

Here, when chemical potential deltamu is taken into consideration, this chemical potential deltamu is expressed by the several 3 following formula.

[0009]

[Equation 3]

- deltamu**=U/M= (RT/M), ln (P/Po)

In this several 3 formula, M expresses the mixed molecular weight of a gasoline. In addition, Mi is made into a gasoline interior division child's molecular weight, Xi is made into mol concentration, and it is specified by sigmaXi=1, then M=sigma (Mi-Xi).

[0010] On the other hand, when an ultrasonic wave spreads the inside of the gasoline which is liquid fuel, the acoustic velocity (henceforth acoustic velocity C) of this

ultrasonic wave is expressed by the several 4 following formula.

[0011]

[Equation 4] C=(V/Vf)1/3(gammaRT/E) 1/2 -- this several 4 V formula expresses the free volume as a liquid of a gasoline, and Vf expresses the free volume as a gas of a gasoline. gamma is given by Cp/Cv. Cp expresses the heat capacity at constant pressure as a gas of a gasoline, and is specified by Cp=sigma (Cpi-Xi). Cv expresses the constant product heat capacity as a gas of a gasoline, and is specified by Cv=sigma (Cvi-Xi). E expresses the Young's modulus as a gas of a gasoline.

[0012] Deformation of a formula with four above obtains the several 5 following formula.

[0013]

[Equation 5] RT=C2(Vf/V) 2 / 3 (E/gamma)

If this several 5 formula is substituted for several 3 formula, the several 6 following formula will be obtained.

[0014]

[Equation 6] **deltamu** -- =(1/M) (Vf/V) (E/gamma) 2 / 3C2, and ln (P/Po)

Here, if free-energy U assumes that it is fixed, the several 7 following formula will be obtained.

[0015]

[Equation 7]

**** -- C2 and deltamu **/**C=K and **{ln(P/Po)}/**C =K {2 C-ln(P/Po)+C2/P}

However, in several 7 formula, it is K=(E/Mgamma) (Vf/V) 2/3.

[0016] a formula with seven above -- setting -- ****deltamu** -- if /**C=0 is materialized, the several 8 following formula will be obtained.

[0017]

[Equation 8] C=2 P-ln (P/Po)

This several 8 P formula shows well that C and P are in inverse proportion, when close to Po. It means, as for this, P being concerned, as for a temperature change, an ultrasonic wave and the vapor pressure of a fuel being concerned when close to Po, and having the

most important functionality [be / nothing].

[0018] Then, this invention aims at an acoustic wave and the vapor pressure of a fuel offering the fuel vapor pressure sensor using a temperature change being concerned and having the most important functionality [be / nothing] paying attention to such a thing.

[0019] Moreover, this invention aims at offering the fuel-injection control unit of the internal combustion engine which used the fuel vapor pressure sensor concerned.

MEANS

[Means for Solving the Problem] An acoustic wave transceiver means to receive this reflected-sound wave when it was in charge of solution of the above-mentioned technical problem, and an acoustic wave is transmitted into liquid fuel according to invention according to claim 1 and this acoustic wave is reflected by reflector (51d) (53), A driving means which drives an acoustic wave transceiver means so that an acoustic wave may be transmitted (61, 62, 63,100), a vapor pressure decision means (64, 65, and 65a --) to determine vapor pressure according to acoustic velocity based on data in which is asked for acoustic velocity of the acoustic wave concerned based on time amount from transmission of an acoustic wave to reception, and relation between vapor pressure of liquid fuel and acoustic velocity is shown A fuel vapor pressure sensor by acoustic wave equipped with 110 and 120 is offered.

[0021] Thus, it can ask for vapor pressure of liquid fuel with a sufficient precision, without being dependent on a temperature sensor, since vapor pressure was determined using data in which relation between vapor pressure of liquid fuel and acoustic velocity of an acoustic wave is shown. In this case, since the above-mentioned data is used, even if density and Young's modulus of liquid fuel differ from each other, regardless of these densities or Young's modulus, vapor pressure of liquid fuel can be uniquely determined with a sufficient precision.

[0022] Here, according to invention according to claim 2, in invention according to claim 1, the above-mentioned data is specified as a straight-line type materialized between the

above-mentioned vapor pressure and the above-mentioned acoustic velocity is also. For this reason, the operation effect according to claim 1 may be secured with a much more sufficient precision.

[0023] Moreover, a fuel-injection control unit of an internal combustion engine concerning invention according to claim 3 is equipped with a fuel-oil-consumption operation means (30 40,140) to calculate fuel oil consumption of the internal combustion engine (E) concerned, and a fuel-injection control means (20, 15, 60) which controls an internal combustion engine's fuel injection according to fuel oil consumption.

[0024] and description the fuel-injection control unit concerned judges description of liquid fuel based on decision vapor pressure of a fuel vapor pressure sensor according to claim 1 or 2 and this fuel vapor pressure sensor to be -- a judgment means (130, 131, 133) and this description -- a judgment by judgment means -- it has an amendment means (150) to amend fuel oil consumption according to description, and to output to a fuel-injection control means by making this amendment injection quantity into fuel oil consumption.

[0025] Thus, it judges that description of liquid fuel is also at decision vapor pressure of this fuel vapor pressure sensor by using a fuel vapor pressure sensor according to claim 1 or 2, and fuel oil consumption can be amended with a sufficient precision by amending fuel oil consumption based on this judgment result, without being dependent on a temperature sensor. Injection control of an internal combustion engine can be performed with a sufficient precision as it is by this also in an amount which suited vapor pressure of liquid fuel.

[0026] here according to invention according to claim 4 -- a fuel-injection control unit of an internal combustion engine according to claim 3 -- setting -- description -- a judgment means -- the description -- a judgment -- the ease of evaporating of liquid fuel -- being based -- carrying out -- an amendment means -- the above -- description -- it amends so that a degree of the ease of carrying out of evaporation of liquid fuel which a judgment shows is large, and fuel oil consumption may be lessened.

[0027] Injection control of an internal combustion engine can be performed with a

sufficient precision as it is by this also in an amount corresponding to the ease of carrying out of evaporation of liquid fuel, consequently the operation effect of invention according to claim 3 can be attained much more certainly.

[0028]

[Embodiment of the Invention] Hereafter, a drawing explains 1 operation gestalt of this invention.

[0029] Drawing 1 shows 1 operation gestalt of the fuel-injection control unit of the 4-cylinder mold internal combustion engine E for automobiles concerning this invention. The internal combustion engine E has the engine main part 10, and gaseous mixture is supplied to this engine main part 10 by that combustion chamber from an intake manifold 11, it burns on the basis of ignition to each point fire plug 12, and he exhausts it from an exhaust pipe 13. the airstream by which an intake manifold 11 is inhaled through an inlet pipe 14 -- the injection fuel (gasoline) of each fuel injector 15 -- mixing -- the above -- the combustion chamber of the engine main part 10 is supplied as gaseous mixture. In addition, in drawing 1 , signs 16 and 17 show a throttle valve and an air filter, respectively. Moreover, ignition control of each point fire plug 12 is carried out by the firing circuit which is not illustrated.

[0030] The gasoline G in a fuel tank 20 is supplied to a fuel injector 15 through piping 22 from the in tank mold fuel pump 21. The fuel pump 21 is formed in the fuel tank 20, and this fuel pump 21 pumps Gasoline G out of the inside of a fuel tank 20 in piping 22. In addition, a sign 23 shows a fuel filter by drawing 1 , and a sign 24 shows a regulator.

[0031] The fuel-injection control unit is equipped with the 30 air flow meter revolution sensor 40, the ultrasonic sensor 50, and the control unit 60 as drawing 1 shows. The revolution sensor 30 detects an internal combustion engine's 10 rotational frequency. An air flow meter 40 detects the amount of the inhalation airstream into an inlet pipe 14.

[0032] The ultrasonic sensor 50 is attached in the fuel tank 20, as drawing 1 and drawing 2 show. This ultrasonic sensor 50 is equipped with the cylindrical barrel 51, and the side attachment wall 21 of a fuel tank 20 is equipped with this barrel 51 through O ring 52 in that upper wall 51a. Thereby, the shaft of a barrel 51 has become in parallel with the low

wall 22 of a fuel tank 20. Moreover, the barrel 51 is located in the gasoline G in a fuel tank 20, and is carrying out the opening of this barrel 51 into Gasoline G in double door regio-oralis 51b which countered that peripheral wall mutually and was formed in it. This is full of Gasoline G through the double door regio-oralis 51b in a barrel 51.

[0033] The ultrasonic sensor 50 is equipped with the ultrasonic transmitter-receiver 53, and this ultrasonic transmitter-receiver 53 is supported by the inner edge of cylinder part 51c of upper wall 51a in same axle within the barrel 51. The ultrasonic transmitter-receiver 53 concerned comes to build an ultrasonic transceiver element (for it to consist of a piezoelectric transducer), and this ultrasonic transmitter-receiver 53 transmits the ultrasonic wave from that ultrasonic transceiver element towards the reflector which is an inner surface of 51d of low walls of a barrel 51 about the inside of Gasoline G from transceiver side 53a. Moreover, the ultrasonic transmitter-receiver 53 receives the ultrasonic wave which is reflected by the reflector of 51d of low walls, and spreads the inside of Gasoline G with the above-mentioned ultrasonic transceiver element through transceiver side 53a, and generates an input signal. In addition, the travelling distance of an ultrasonic wave is specified in the distance D between transceiver side 53a of the ultrasonic transmitter-receiver 53, and the reflector of 51d of low walls, as drawing 2 shows.

[0034] The control unit 60 is equipped with the frequency generator 61, and this frequency generator 61 generates the pulse signal of predetermined frequency (for example, 200kHz) with reset by the microcomputer 67 mentioned later. A gate circuit 62 cuts off the pulse signal produced from the frequency generator 61 one by one at a a fixed number of [every] (for example, ten pieces) fixed gap, forms a burst signal one by one in the lump of the pulse signal of these one constants each, and outputs it to the actuation circuit 63. In addition, the output gap from the gate circuit 62 of each burst signal is set up a little longer than the time amount required for the ultrasonic transmitter-receiver 53 to receive the reflective ultrasonic wave after transmission of an ultrasonic wave.

[0035] The burst signal by which a sequential output is carried out from a gate circuit 62 is amplified, it generates as a driving signal, and the actuation circuit 63 is outputted to

the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53 from cylinder part 51c of a barrel 51 through Wiring L. This means that the ultrasonic transmitter-receiver 53 generates an ultrasonic wave for every driving signal from the actuation circuit 63 with the ultrasonic transceiver element.

[0036] The through input of the wiring L is carried out, the input signal from the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53 is amplified, and an amplifying circuit 64 outputs it to a comparator 65 as an amplification signal. A comparator 65 compares the level of the amplification signal of an amplifying circuit 64 with the reference voltage from reference voltage setter 65a. And a comparator 65 generates a comparison signal in high level, when the level of the above-mentioned amplification signal is higher than the above-mentioned reference voltage, and when the level of the above-mentioned amplification signal is lower than the above-mentioned reference voltage, it makes this comparison signal a low level. Here, the end point of the ultrasonic travelling period which the standup to the high level of the comparison signal of a comparator 65 mentions later is specified.

[0037] With reset by the microcomputer 67, the travelling period counter 66 carries out counting of the period to the standup to the high level of the comparison signal from a comparator 65, and outputs it to a microcomputer 67 by using these enumerated data as enumeration data.

[0038] According to the flow chart shown by drawing 3, a microcomputer 67 performs a computer program and performs data processing which control of the frequency generator 61 and the travelling period counter 66 takes, and data processing of the travelling period of an ultrasonic wave.

[0039] In this operation gestalt constituted as mentioned above, if a microcomputer 67 starts activation of a computer program according to the flow chart of drawing 3 , in step 100, a reset signal will be outputted to the frequency generator 61 and the travelling period counter 66. Then, the frequency generator 61 is reset based on the reset signal concerned, and carries out sequential generating of the pulse signal of the above-mentioned predetermined frequency. Moreover, the travelling period counter 66 is also

reset by the above-mentioned reset signal, and carries out counting of the clock signal from a microcomputer 67.

[0040] A deer is carried out, and a gate circuit 62 cuts off each pulse signal from the frequency generator 61 a fixed number of [every], generates a burst signal one by one, and outputs it to the actuation circuit 63. For this reason, this actuation circuit 63 outputs a driving signal to an ultrasonic sensor 50 based on each burst signal from a gate circuit 62.

[0041] Then, in this ultrasonic sensor 50, the ultrasonic transmitter-receiver 53 transmits an ultrasonic wave into Gasoline G based on each driving signal of the actuation circuit 63 from that ultrasonic transceiver element. Here, transmission of the ultrasonic wave of the ultrasonic transmitter-receiver 53 is made for every output of the driving signal from the actuation circuit 63.

[0042] If a deer is carried out, for example, an ultrasonic wave is transmitted from the ultrasonic transmitter-receiver 53 based on one driving signal from the actuation circuit 63, it is reflected by the inner surface which is 51d of low walls of a barrel 51, and the ultrasonic wave concerned will turn the inside of Gasoline G to the ultrasonic transmitter-receiver 53, and will spread it. Then, if the reflective ultrasonic wave concerned is received by the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53, this ultrasonic transceiver element will generate an input signal, and will output it to an amplifying circuit 64.

[0043] When an amplifying circuit 64 amplifies the input signal from the ultrasonic transmitter-receiver 53 and generates an amplification signal, the level of this amplification signal is compared with the reference voltage of reference voltage generator 65a by the comparator 65. Here, if the level of the above-mentioned amplification signal becomes higher than the above-mentioned reference voltage, the output of a comparator 65 will start high-level.

[0044] In connection with this, the travelling period counter 66 outputs the enumerated data to a microcomputer 67 as data showing the travelling period enumerated data of an ultrasonic wave. For this reason, the travelling period enumerated-data data concerned is

inputted into a microcomputer 67 at step 110.

[0045] Then, in step 120, the acoustic velocity C of an ultrasonic wave does the division of the travelling distance D (refer to drawing 2) to 1/2 of the travelling period equivalent to the above-mentioned travelling period enumerated data being, and is searched for. Subsequently, the vapor pressure P of Gasoline G is determined according to acoustic velocity C based on the straight-line data showing the vapor pressure P of the gasoline G shown by drawing 4 , and relation with acoustic velocity C. However, the straight-line data of drawing 4 is given by P=-0.26655C+344.3044.

[0046] Thus, after determining vapor pressure P, in step 130, the comparison test of the vapor pressure P is carried out to the predetermined vapor pressure Po. Here, the predetermined vapor pressure Po is used in order that Gasoline G may judge a light gasoline or a heavy gasoline, P>Po corresponds to a heavy gasoline, and P<=Po corresponds to a light gasoline. Here, it means that a light gasoline is a gasoline which is easy to evaporate, and, on the other hand, a heavy gasoline means that it is the gasoline which cannot evaporate easily rather than a light gasoline.

[0047] A deer is carried out, by step 130, if it is P>Po, Gasoline G will be judged at step 131 to be a heavy gasoline, and the memory of a microcomputer 67 memorizes as a heavy gasoline at step 132. On the other hand, if it is P<=Po, in step 133, Gasoline G will be judged to be a light gasoline and will be memorized by the memory of a microcomputer 67 as a light gasoline at step 134.

[0048] If the description of Gasoline G is judged as mentioned above, in step 140, the basic injection quantity (henceforth the fuel basic injection quantity Q) of the gasoline G to an internal combustion engine 10 will be computed according to each detection output of the revolution sensor 30 and an air flow meter 40. Subsequently, in step 150, the above-mentioned fuel basic injection quantity Q is amended according to the content of storage in step 132 or step 134.

[0049] Since Gasoline G tends to evaporate when it is a light gasoline, specifically, it is amended as amendment injection quantity so that the fuel basic injection quantity Q may be decreased. On the other hand, since Gasoline G cannot evaporate easily when it is a

heavy gasoline, it is amended as amendment injection quantity so that the fuel basic injection quantity Q may be increased.

[0050] In step 160, the above-mentioned amendment injection quantity is outputted to a fuel injector 15 after such amendment. For this reason, a fuel injector 15 injects a gasoline in the intake manifold 11 of the engine main part 10 with the amendment injection quantity concerned. In connection with this, it is mixed with the inhalation inhalation-of-air style into an inlet pipe 14, and this injection gasoline is supplied to the combustion chamber of the engine main part 10 as gaseous mixture.

[0051] Moreover, if an internal combustion engine's ignition timing is determined in step 170, this ignition timing will be outputted to the above-mentioned firing circuit at step 180, and this firing circuit will light an ignition plug 15. Thereby, the gaseous mixture of a combustion chamber burns.

[0052] It becomes possible to constitute the fuel vapor pressure sensor which can ask for vapor pressure with a sufficient precision, without being dependent on a temperature sensor, since it asked for the vapor pressure of a gasoline from the acoustic velocity of an ultrasonic wave based on the graph of drawing 4 using the ultrasonic sensor 50 as explained above.

[0053] Moreover, the degree of the ease of carrying out of the evaporation which is the description of a gasoline can be judged with a sufficient precision by using such a fuel vapor pressure sensor. Consequently, an internal combustion engine's fuel oil consumption can be obtained with a sufficient precision according to the description of a gasoline. Therefore, according to such fuel oil consumption, fuel-injection control of an internal combustion engine can be performed with a sufficient precision.

[0054] Moreover, without being influenced by these even if the Young's modulus and density change with classes of gasoline since it asked for vapor pressure from the acoustic velocity of an ultrasonic wave as mentioned above, vapor pressure can be obtained uniquely, consequently according to such vapor pressure, the decision of fuel oil consumption can carry out with a sufficient precision.

[0055] Incidentally, the relation between the RAID vapor pressure RVP showing the

description of a gasoline and the vapor pressure P of a gasoline is given by the several 9 following formula.

[0056]

[Equation 9] logP=6.15- (1912. 65-311xlogRVP)/Tk -- in this several 9, it is Tk=T +273. Moreover, T is absolute temperature.

[0057] The physical meaning of the RAID vapor pressure RVP shows the evaporation property of a fuel, and expresses the vapor pressure at the time of 37.8 degrees C. It compares with the vapor pressure for which it asked by acoustic velocity as the above-mentioned operation gestalt described this.

[0058] The RAID vapor pressure RVP is given for every gasoline, and is used by an internal combustion engine's conformance test etc. Since the value of this RAID vapor pressure RVP fixes temperature as fixed, temperature compensation is needed for calculation of vapor pressure. Moreover, since the value of the RAID vapor pressure RVP is changing from immediately after gasoline shipment for evaporation of a volatile constituent, it has actually that the value of the RAID vapor pressure RVP under measurement is not clear.

[0059] On the other hand, according to the above-mentioned operation gestalt, it is. Since it can ask for vapor pressure directly from acoustic velocity, the value of the RAID vapor pressure RVP is not needed, and since the temperature sensor is unnecessary, the vapor pressure of a gasoline can be obtained with a sufficient precision, and, moreover, the inclusion to a actual internal combustion engine is easy. In addition, in several 1 formula, between 0.6 thru/or 0.9 atmospheric pressures (0.6 thru/or 0.9MPa(s)) is considered to be the right as a gasoline.

[0060] In addition, even if it measures the travelling period in the above-mentioned measuring object using various kinds of acoustic waves, such as an audible-sound wave, without restricting to an ultrasonic wave in operation of this invention, the same operation effect as the above-mentioned operation gestalt can be attained.

[0061] Moreover, the graph of drawing 4 stated with the above-mentioned operation gestalt may be suitably changed according to the class of gasoline. Moreover, not only

about a gasoline but about various kinds of liquid fuel, the same data can be substantially obtained with the graph of drawing 4 , consequently the same operation effect can be substantially attained with the above-mentioned operation gestalt based on various kinds of liquid fuel concerned.

[0062] Moreover, you may make it the both sides of an ultrasonic transmitting element and an ultrasonic receiving element constitute the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53 in operation of this invention.

[0063] Moreover, this invention may be applied to the fuel-injection control unit of the internal combustion engine which has various kinds of numbers of cylinders, such as 6-cylinder, without restricting to a 4-cylinder mold internal combustion engine in operation of this invention.

[0064] Moreover, it is in charge of operation of this invention, and the amendment in step 150 may be made to perform amendment in step 150 to the injection quantity after the amendment of the basic injection quantity based on the detection value of water temperature and others of an internal combustion engine, without restricting to the basic injection quantity.

[0065] Moreover, it is in charge of operation of this invention, and it may be made to perform the judgment in step 130 also including the nature gasoline of inside, without restricting to a light gasoline and a heavy gasoline.

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[Drawing 1] It is the block diagram showing 1 operation gestalt of this invention.

[Drawing 2] They are the ultrasonic sensor of drawing 1 , and the detail drawing of a control unit.

[Drawing 3] It is the flow chart which shows an operation of the microcomputer of drawing 2 .

[Drawing 4] It is the graph which shows the relation between the vapor pressure of a

gasoline, and the acoustic velocity of an ultrasonic wave.

[Description of Notations]

20 [-- An ultrasonic sensor, 53 / -- An ultrasonic transmitter-receiver, 60 / -- A control unit, 61 / -- A frequency generator, 62 / -- A gate circuit, 63 / -- An actuation circuit, 64 / -- An amplifying circuit, 65 / -- A comparator, 65a / -- A reference voltage setter, 66 / -- A travelling period counter, 67 / -- Microcomputer.] -- A fuel tank, 30 -- A revolution sensor, 40 -- An air flow meter, 50

DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[The technical field to which invention belongs] This invention relates to an internal combustion engine's fuel-injection control unit using the fuel vapor pressure sensor suitable for detecting the vapor pressure of liquid fuel, such as a gasoline, based on various kinds of acoustic waves, such as an audible-sound wave and an ultrasonic wave, and this fuel vapor pressure sensor.

[0002]

[Description of the Prior Art] Conventionally, generally the measuring method of the description of a gasoline has some which were defined in JIS. Even if it does not pass over this measuring method on mere criteria to the last but it uses the measurement result by the measuring method concerned for the gasoline of the internal combustion engine for mount as it is, it cannot control the injection quantity of an internal combustion engine's gasoline with a sufficient precision, for example.

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In this several 1 equation, R expresses the gas constant in a gaseous equation of state, and T expresses absolute temperature. Moreover, U expresses free energy and is given by the several 2 following formula.

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addition, Mi is made into a gasoline interior division child's molecular weight, Xi is made into mol concentration, and it is specified by sigmaXi=1, then M=sigma (Mi-Xi).

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[Equation 4] C=(V/Vf)1/3(gammaRT/E) 1/2 -- this several 4 V formula expresses the free volume as a liquid of a gasoline, and Vf expresses the free volume as a gas of a gasoline. gamma is given by Cp/Cv. Cp expresses the heat capacity at constant pressure as a gas of a gasoline, and is specified by Cp=sigma (Cpi-Xi). Cv expresses the constant product heat capacity as a gas of a gasoline, and is specified by Cv=sigma (Cvi-Xi). E expresses the Young's modulus as a gas of a gasoline.

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[0018] Then, this invention aims at an acoustic wave and the vapor pressure of a fuel offering the fuel vapor pressure sensor using a temperature change being concerned and having the most important functionality [be / nothing] paying attention to such a thing.

[0019] Moreover, this invention aims at offering the fuel-injection control unit of the internal combustion engine which used the fuel vapor pressure sensor concerned.

[0020]

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[0021] Thus, it can ask for vapor pressure of liquid fuel with a sufficient precision, without being dependent on a temperature sensor, since vapor pressure was determined using data in which relation between vapor pressure of liquid fuel and acoustic velocity of an acoustic wave is shown. In this case, since the above-mentioned data is used, even if density and Young's modulus of liquid fuel differ from each other, regardless of these densities or Young's modulus, vapor pressure of liquid fuel can be uniquely determined with a sufficient precision.

[0022] Here, according to invention according to claim 2, in invention according to claim 1, the above-mentioned data is specified as a straight-line type materialized between the above-mentioned vapor pressure and the above-mentioned acoustic velocity is also. For this reason, the operation effect according to claim 1 may be secured with a much more sufficient precision.

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[0026] here according to invention according to claim 4 -- a fuel-injection control unit of an internal combustion engine according to claim 3 -- setting -- description -- a judgment means -- the description -- a judgment -- the ease of evaporating of liquid fuel -- being based -- carrying out -- an amendment means -- the above -- description -- it amends so that a degree of the ease of carrying out of evaporation of liquid fuel which a judgment

shows is large, and fuel oil consumption may be lessened.

[0027] Injection control of an internal combustion engine can be performed with a sufficient precision as it is by this also in an amount corresponding to the ease of carrying out of evaporation of liquid fuel, consequently the operation effect of invention according to claim 3 can be attained much more certainly.

[0028]

[Embodiment of the Invention] Hereafter, a drawing explains 1 operation gestalt of this invention.

[0029] Drawing 1 shows 1 operation gestalt of the fuel-injection control unit of the 4-cylinder mold internal combustion engine E for automobiles concerning this invention. The internal combustion engine E has the engine main part 10, and gaseous mixture is supplied to this engine main part 10 by that combustion chamber from an intake manifold 11, it burns on the basis of ignition to each point fire plug 12, and he exhausts it from an exhaust pipe 13. the airstream by which an intake manifold 11 is inhaled through an inlet pipe 14 -- the injection fuel (gasoline) of each fuel injector 15 -- mixing -- the above -- the combustion chamber of the engine main part 10 is supplied as gaseous mixture. In addition, in drawing 1 , signs 16 and 17 show a throttle valve and an air filter, respectively. Moreover, ignition control of each point fire plug 12 is carried out by the firing circuit which is not illustrated.

[0030] The gasoline G in a fuel tank 20 is supplied to a fuel injector 15 through piping 22 from the in tank mold fuel pump 21. The fuel pump 21 is formed in the fuel tank 20, and this fuel pump 21 pumps Gasoline G out of the inside of a fuel tank 20 in piping 22. In addition, a sign 23 shows a fuel filter by drawing 1 , and a sign 24 shows a regulator.

[0031] The fuel-injection control unit is equipped with the 30 air flow meter revolution sensor 40, the ultrasonic sensor 50, and the control unit 60 as drawing 1 shows. The revolution sensor 30 detects an internal combustion engine's 10 rotational frequency. An air flow meter 40 detects the amount of the inhalation airstream into an inlet pipe 14.

[0032] The ultrasonic sensor 50 is attached in the fuel tank 20, as drawing 1 and drawing 2 show. This ultrasonic sensor 50 is equipped with the cylindrical barrel 51, and the side

attachment wall 21 of a fuel tank 20 is equipped with this barrel 51 through O ring 52 in that upper wall 51a. Thereby, the shaft of a barrel 51 has become in parallel with the low wall 22 of a fuel tank 20. Moreover, the barrel 51 is located in the gasoline G in a fuel tank 20, and is carrying out the opening of this barrel 51 into Gasoline G in double door regio-oralis 51b which countered that peripheral wall mutually and was formed in it. This is full of Gasoline G through the double door regio-oralis 51b in a barrel 51.

[0033] The ultrasonic sensor 50 is equipped with the ultrasonic transmitter-receiver 53, and this ultrasonic transmitter-receiver 53 is supported by the inner edge of cylinder part 51c of upper wall 51a in same axle within the barrel 51. The ultrasonic transmitter-receiver 53 concerned comes to build an ultrasonic transceiver element (for it to consist of a piezoelectric transducer), and this ultrasonic transmitter-receiver 53 transmits the ultrasonic wave from that ultrasonic transceiver element towards the reflector which is an inner surface of 51d of low walls of a barrel 51 about the inside of Gasoline G from transceiver side 53a. Moreover, the ultrasonic transmitter-receiver 53 receives the ultrasonic wave which is reflected by the reflector of 51d of low walls, and spreads the inside of Gasoline G with the above-mentioned ultrasonic transceiver element through transceiver side 53a, and generates an input signal. In addition, the travelling distance of an ultrasonic wave is specified in the distance D between transceiver side 53a of the ultrasonic transmitter-receiver 53, and the reflector of 51d of low walls, as drawing 2 shows.

[0034] The control unit 60 is equipped with the frequency generator 61, and this frequency generator 61 generates the pulse signal of predetermined frequency (for example, 200kHz) with reset by the microcomputer 67 mentioned later. A gate circuit 62 cuts off the pulse signal produced from the frequency generator 61 one by one at a a fixed number of [every] (for example, ten pieces) fixed gap, forms a burst signal one by one in the lump of the pulse signal of these one constants each, and outputs it to the actuation circuit 63. In addition, the output gap from the gate circuit 62 of each burst signal is set up a little longer than the time amount required for the ultrasonic transmitter-receiver 53 to receive the reflective ultrasonic wave after transmission of an ultrasonic wave.

[0035] The burst signal by which a sequential output is carried out from a gate circuit 62 is amplified, it generates as a driving signal, and the actuation circuit 63 is outputted to the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53 from cylinder part 51c of a barrel 51 through Wiring L. This means that the ultrasonic transmitter-receiver 53 generates an ultrasonic wave for every driving signal from the actuation circuit 63 with the ultrasonic transceiver element.

[0036] The through input of the wiring L is carried out, the input signal from the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53 is amplified, and an amplifying circuit 64 outputs it to a comparator 65 as an amplification signal. A comparator 65 compares the level of the amplification signal of an amplifying circuit 64 with the reference voltage from reference voltage setter 65a. And a comparator 65 generates a comparison signal in high level, when the level of the above-mentioned amplification signal is higher than the above-mentioned reference voltage, and when the level of the above-mentioned amplification signal is lower than the above-mentioned reference voltage, it makes this comparison signal a low level. Here, the end point of the ultrasonic travelling period which the standup to the high level of the comparison signal of a comparator 65 mentions later is specified.

[0037] With reset by the microcomputer 67, the travelling period counter 66 carries out counting of the period to the standup to the high level of the comparison signal from a comparator 65, and outputs it to a microcomputer 67 by using these enumerated data as enumeration data.

[0038] According to the flow chart shown by drawing 3, a microcomputer 67 performs a computer program and performs data processing which control of the frequency generator 61 and the travelling period counter 66 takes, and data processing of the travelling period of an ultrasonic wave.

[0039] In this operation gestalt constituted as mentioned above, if a microcomputer 67 starts activation of a computer program according to the flow chart of drawing 3 , in step 100, a reset signal will be outputted to the frequency generator 61 and the travelling period counter 66. Then, the frequency generator 61 is reset based on the reset signal

concerned, and carries out sequential generating of the pulse signal of the above-mentioned predetermined frequency. Moreover, the travelling period counter 66 is also reset by the above-mentioned reset signal, and carries out counting of the clock signal from a microcomputer 67.

[0040] A deer is carried out, and a gate circuit 62 cuts off each pulse signal from the frequency generator 61 a fixed number of [every], generates a burst signal one by one, and outputs it to the actuation circuit 63. For this reason, this actuation circuit 63 outputs a driving signal to an ultrasonic sensor 50 based on each burst signal from a gate circuit 62.

[0041] Then, in this ultrasonic sensor 50, the ultrasonic transmitter-receiver 53 transmits an ultrasonic wave into Gasoline G based on each driving signal of the actuation circuit 63 from that ultrasonic transceiver element. Here, transmission of the ultrasonic wave of the ultrasonic transmitter-receiver 53 is made for every output of the driving signal from the actuation circuit 63.

[0042] If a deer is carried out, for example, an ultrasonic wave is transmitted from the ultrasonic transmitter-receiver 53 based on one driving signal from the actuation circuit 63, it is reflected by the inner surface which is 51d of low walls of a barrel 51, and the ultrasonic wave concerned will turn the inside of Gasoline G to the ultrasonic transmitter-receiver 53, and will spread it. Then, if the reflective ultrasonic wave concerned is received by the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53, this ultrasonic transceiver element will generate an input signal, and will output it to an amplifying circuit 64.

[0043] When an amplifying circuit 64 amplifies the input signal from the ultrasonic transmitter-receiver 53 and generates an amplification signal, the level of this amplification signal is compared with the reference voltage of reference voltage generator 65a by the comparator 65. Here, if the level of the above-mentioned amplification signal becomes higher than the above-mentioned reference voltage, the output of a comparator 65 will start high-level.

[0044] In connection with this, the travelling period counter 66 outputs the enumerated

data to a microcomputer 67 as data showing the travelling period enumerated data of an ultrasonic wave. For this reason, the travelling period enumerated-data data concerned is inputted into a microcomputer 67 at step 110.

[0045] Then, in step 120, the acoustic velocity C of an ultrasonic wave does the division of the travelling distance D (refer to drawing 2) to 1/2 of the travelling period equivalent to the above-mentioned travelling period enumerated data being, and is searched for. Subsequently, the vapor pressure P of Gasoline G is determined according to acoustic velocity C based on the straight-line data showing the vapor pressure P of the gasoline G shown by drawing 4 , and relation with acoustic velocity C. However, the straight-line data of drawing 4 is given by $P=-0.26655C+344.3044$.

[0046] Thus, after determining vapor pressure P, in step 130, the comparison test of the vapor pressure P is carried out to the predetermined vapor pressure Po. Here, the predetermined vapor pressure Po is used in order that Gasoline G may judge a light gasoline or a heavy gasoline, $P>Po$ corresponds to a heavy gasoline, and $P<=Po$ corresponds to a light gasoline. Here, it means that a light gasoline is a gasoline which is easy to evaporate, and, on the other hand, a heavy gasoline means that it is the gasoline which cannot evaporate easily rather than a light gasoline.

[0047] A deer is carried out, by step 130, if it is $P>Po$, Gasoline G will be judged at step 131 to be a heavy gasoline, and the memory of a microcomputer 67 memorizes as a heavy gasoline at step 132. On the other hand, if it is $P<=Po$, in step 133, Gasoline G will be judged to be a light gasoline and will be memorized by the memory of a microcomputer 67 as a light gasoline at step 134.

[0048] If the description of Gasoline G is judged as mentioned above, in step 140, the basic injection quantity (henceforth the fuel basic injection quantity Q) of the gasoline G to an internal combustion engine 10 will be computed according to each detection output of the revolution sensor 30 and an air flow meter 40. Subsequently, in step 150, the above-mentioned fuel basic injection quantity Q is amended according to the content of storage in step 132 or step 134.

[0049] Since Gasoline G tends to evaporate when it is a light gasoline, specifically, it is

amended as amendment injection quantity so that the fuel basic injection quantity Q may be decreased. On the other hand, since Gasoline G cannot evaporate easily when it is a heavy gasoline, it is amended as amendment injection quantity so that the fuel basic injection quantity Q may be increased.

[0050] In step 160, the above-mentioned amendment injection quantity is outputted to a fuel injector 15 after such amendment. For this reason, a fuel injector 15 injects a gasoline in the intake manifold 11 of the engine main part 10 with the amendment injection quantity concerned. In connection with this, it is mixed with the inhalation inhalation-of-air style into an inlet pipe 14, and this injection gasoline is supplied to the combustion chamber of the engine main part 10 as gaseous mixture.

[0051] Moreover, if an internal combustion engine's ignition timing is determined in step 170, this ignition timing will be outputted to the above-mentioned firing circuit at step 180, and this firing circuit will light an ignition plug 15. Thereby, the gaseous mixture of a combustion chamber burns.

[0052] It becomes possible to constitute the fuel vapor pressure sensor which can ask for vapor pressure with a sufficient precision, without being dependent on a temperature sensor, since it asked for the vapor pressure of a gasoline from the acoustic velocity of an ultrasonic wave based on the graph of drawing 4 using the ultrasonic sensor 50 as explained above.

[0053] Moreover, the degree of the ease of carrying out of the evaporation which is the description of a gasoline can be judged with a sufficient precision by using such a fuel vapor pressure sensor. Consequently, an internal combustion engine's fuel oil consumption can be obtained with a sufficient precision according to the description of a gasoline. Therefore, according to such fuel oil consumption, fuel-injection control of an internal combustion engine can be performed with a sufficient precision.

[0054] Moreover, without being influenced by these even if the Young's modulus and density change with classes of gasoline since it asked for vapor pressure from the acoustic velocity of an ultrasonic wave as mentioned above, vapor pressure can be obtained uniquely, consequently according to such vapor pressure, the decision of fuel oil

consumption can carry out with a sufficient precision.

[0055] Incidentally, the relation between the RAID vapor pressure RVP showing the description of a gasoline and the vapor pressure P of a gasoline is given by the several 9 following formula.

[0056]

[Equation 9] logP=6.15- (1912. 65-311xlogRVP)/Tk -- in this several 9, it is Tk=T +273. Moreover, T is absolute temperature.

[0057] The physical meaning of the RAID vapor pressure RVP shows the evaporation property of a fuel, and expresses the vapor pressure at the time of 37.8 degrees C. It compares with the vapor pressure for which it asked by acoustic velocity as the above-mentioned operation gestalt described this.

[0058] The RAID vapor pressure RVP is given for every gasoline, and is used by an internal combustion engine's conformance test etc. Since the value of this RAID vapor pressure RVP fixes temperature as fixed, temperature compensation is needed for calculation of vapor pressure. Moreover, since the value of the RAID vapor pressure RVP is changing from immediately after gasoline shipment for evaporation of a volatile constituent, it has actually that the value of the RAID vapor pressure RVP under measurement is not clear.

[0059] On the other hand, according to the above-mentioned operation gestalt, it is. Since it can ask for vapor pressure directly from acoustic velocity, the value of the RAID vapor pressure RVP is not needed, and since the temperature sensor is unnecessary, the vapor pressure of a gasoline can be obtained with a sufficient precision, and, moreover, the inclusion to a actual internal combustion engine is easy. In addition, in several 1 formula, between 0.6 thru/or 0.9 atmospheric pressures (0.6 thru/or 0.9MPa(s)) is considered to be the right as a gasoline.

[0060] In addition, even if it measures the travelling period in the above-mentioned measuring object using various kinds of acoustic waves, such as an audible-sound wave, without restricting to an ultrasonic wave in operation of this invention, the same operation effect as the above-mentioned operation gestalt can be attained.

[0061] Moreover, the graph of drawing 4 stated with the above-mentioned operation gestalt may be suitably changed according to the class of gasoline. Moreover, not only about a gasoline but about various kinds of liquid fuel, the same data can be substantially obtained with the graph of drawing 4 , consequently the same operation effect can be substantially attained with the above-mentioned operation gestalt based on various kinds of liquid fuel concerned.

[0062] Moreover, you may make it the both sides of an ultrasonic transmitting element and an ultrasonic receiving element constitute the ultrasonic transceiver element of the ultrasonic transmitter-receiver 53 in operation of this invention.

[0063] Moreover, this invention may be applied to the fuel-injection control unit of the internal combustion engine which has various kinds of numbers of cylinders, such as 6-cylinder, without restricting to a 4-cylinder mold internal combustion engine in operation of this invention.

[0064] Moreover, it is in charge of operation of this invention, and the amendment in step 150 may be made to perform amendment in step 150 to the injection quantity after the amendment of the basic injection quantity based on the detection value of water temperature and others of an internal combustion engine, without restricting to the basic injection quantity.

[0065] Moreover, it is in charge of operation of this invention, and it may be made to perform the judgment in step 130 also including the nature gasoline of inside, without restricting to a light gasoline and a heavy gasoline.

CLAIMS

[Claim(s)]

[Claim 1] A fuel vapor pressure sensor by acoustic wave characterized by providing the following An acoustic wave transceiver means to receive this reflected-sound wave when an acoustic wave is transmitted and this acoustic wave is reflected by reflector (51d) into liquid fuel (53) A driving means which drives said acoustic wave transceiver means so

that said acoustic wave may be transmitted (61, 62, 63,100) A vapor pressure decision means to determine said vapor pressure according to said acoustic velocity based on data in which is asked for acoustic velocity of the acoustic wave concerned based on time amount from transmission of said acoustic wave to reception, and relation between vapor pressure of said liquid fuel and acoustic velocity is shown (64, 65, 65a, 110, 120)

[Claim 2] Said data is a fuel vapor pressure sensor by acoustic wave according to claim 1 characterized by specifying that a straight-line type materialized between said vapor pressure and said acoustic velocity is also.

[Claim 3] A fuel-injection control unit equipped with a fuel-oil-consumption operation means (30 40,140) characterized by providing the following to calculate an internal combustion engine's (E)'s fuel oil consumption, and a fuel-injection control means (20, 15, 60) which controls an internal combustion engine's fuel injection according to said fuel oil consumption A fuel vapor pressure sensor according to claim 1 or 2 description which judges description of said liquid fuel based on decision vapor pressure of this fuel vapor pressure sensor -- a judgment means (130, 131, 133) this description -- a judgment by judgment means -- an amendment means (150) to amend said fuel oil consumption according to description, and to output to said fuel-injection control means by making this amendment injection quantity into said fuel oil consumption

[Claim 4] said description -- a judgment means -- the description -- a judgment -- the ease of evaporating of said liquid fuel -- being based -- carrying out -- said amendment means -- said description -- a fuel-injection control unit of an internal combustion engine according to claim 3 characterized by amending so that a degree of the ease of carrying out of evaporation of said liquid fuel which a judgment shows is large, and said fuel oil consumption may be lessened.